TREMAINE & ASSOCIATES
Archaeology ≈ GIS ≈ Geophysics

February 20, 2017

Delta Stewardship Council
Dustin Jones
980 9th Street, Ste. 1500
Sacramento, CA 95814

Re: Comments on Risk Reduction Policies and Delta Levees Investment Strategy

Dear Mr. Jones,

We recently attended a Public Meeting on the draft Delta Risk Reduction Strategy held in Walnut Grove, January 24th, 2017. At that meeting, we participated in a roundtable discussion on investment priorities for levee improvements and maintenance. Subsequently, we reviewed the Risk Analysis Methodology document dated July 2016 and offer the following comments.

Levee vulnerability ratings, as currently derived using the DSCs Decision Support Tool computer model, are based on overly simplistic assumptions and very limited datasets. Further, these ratings are made without clearly accounting for associated uncertainties that are key to making sound and defensible flood risk management decisions.

Simplistic Assumptions
The Risk Analysis Methodology, as outlined for the DLIS (July 2016), relies primarily upon levee geometry to identify the weakest links in levees, calculating vulnerabilities solely based on the lowest crest elevations (Section 4.4.2, p.79). This reliance is made despite acknowledging a host of other possible hazard types and failure mechanisms. Because the Delta levees are heterogeneous in composition with countless internal irregularities (localized points of weakness having no association with crest elevation), it seems irresponsible to develop a computer model that doesn't take them into account. A more robust approach would be an assessment of Total Conditional Performance (the combined probabilities of all potential modes of failure).

It is also troubling that the DSC is only concerned with *breached* levees, explicitly disregarding *damaged* levees (Section 4.3.1, p.48). Experts agree that the cumulative effects of seepage under and through levees, especially during repetitive high water events, can compromise levee safety, resulting in progressively deteriorating conditions due to loss of soil cohesion, density, and differential settlement (causing the formation of cracks, fissures, sink holes, sand boils, and piping). It is our contention that weak spots, other than lowest crest elevations, should be identified and included in risk analyses/investment decisions.

Address: 3380 Industrial Blvd, Ste. 1, West Sacramento, CA 95691 Phone: 916-637-9717

Limited Data
According to the Risk Analysis Methodology document (July 2016), the calculus for arriving at decisions regarding Delta Levee Investments is based on "best available existing data for levee hazards and vulnerabilities". The specific types of data, however, are not outlined so it is impossible to evaluate the quality of the datasets. This is especially concerning since, according to the Independent Science Panel Review (July 2015, p. 7), the accuracy and precision of the model methodology is based on "relatively simple (mostly linear) equations and calculations, and thus its accuracy and precision are heavily dependent on the quantity and quality of the available data". If the reason the DSC computer model only focuses on elevation is due to a lack of data, then the first priority in investments should be on bolstering the data input. This will require a thorough assessment of the hazard data gaps. We recommend that prioritization of investments include allocations for improving the baseline data used to characterize the levee interior and foundation conditions (e.g., mobile ground-based geophysical data & geotechnical data).

Uncertainty Analyses
The Independent Science Panel, reviewing the Risk Analysis Methodology (July 2015, p.8), strongly recommended the DSC include a plan on how *uncertainties* will be identified, evaluated, and considered in the levee priorities analysis, as well as perform *sensitivity* calculations. In going over the subsequent Risk Analysis Methodology document (July 2016), it does not appear that sufficient attention has been paid to this particular issue. Perhaps an existing software package could be adopted? REFRAME, developed by Jim Hall and others at Newcastle University of the United Kingdom, was designed to run complex multi-dimensional analyses to support strategic flood risk management decision-making. It is capable of calculating not only uncertainty in reliability assessments, but sensitivity analyses to determine the influence variance in load and resistance has on reliability indices.

Existing Data NOT Included in the Risk-Reduction/Investment Model
Many of the Delta Levee Districts, receiving FEMA Hazards Mitigation Grant monies prior to the collapse of the economy, funded the collection of geophysics data to identify localized deficiencies. These existing data should be integrated into the risk reduction/investment model. In addition, data collection of the remaining islands should be completed as part of the baseline. This would allow for a comprehensive delta-wide analysis correlating the distribution of anomalies with underlying geology, hydrodynamics, natural history, and previous documented levee failures with the aim of developing a predictive model.

Value of Geophysical Data
Several important objectives can be addressed with geophysical data, providing *multiple investment benefits*. First, rapidly collected, cost-effective geophysical data can raise confidence in levee integrity assessments and predictions regarding levee performance by helping to delineate variability in materials both within and underneath

the levees. Secondly, the data can be used to detect buried objects, including undocumented legacy pipes and cables, acknowledged as potential flood hazards by the Central Valley Flood Protection Board (CVFP Plan 2017 Update, Appendix A, Issue Summary #5). Thirdly, geophysical data can help in better positioning geotechnical bore sites.

Modernizing the Levee Inspection Program
One step toward modernizing the existing visual inspection program would be to implement a subsurface monitoring effort through comparison of periodically collected geophysical data sets, especially baseline with conditions following prolonged high water events. The aim of this monitoring effort would be to identify and flag significant changes in electrical properties of levees and foundations potentially representing distressed reaches with developing internal erosion problems. This approach is similar to one taken by Benes et al. (2011) in the Czech Republic. Another step might be to monitor surface deformations (subsidence & slope instabilities) over wide swaths of the Delta using airborne Interferometric Synthetic Aperture Radar (InSAR) data. Lastly, the DSC might consider affordable sensing technologies for real-time field monitoring in locations with past performance problems.

Respectfully,

Kim Tremaine

Kim Tremaine & John Lopez
Principals, Tremaine & Associates, Inc.